Visuo-Haptic Memory Representation and the Influence of Verbal Processing

BY

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Abstract

Recent research suggests that there is a verbal component to the shared visual-haptic memory representation. The current study examined the nature of visual-haptic memory representations among 45 undergraduate participants. Participants saw novel objects in one modality (visual or haptic) and then were presented with another object in a different modality and were asked to determine if the two objects were the same or not. Some participants completed the task with no distractor, while others completed a visual distractor task, and others did a verbal distractor task. The distractor tasks did not affect the performance of participants, and this finding did not support my hypothesis that there is a verbal code for the visual-haptic memory representation. I also observed that participants responded faster for incongruent trials and when haptic examination of the stimulus occurred first. Moreover, there was a significant difference in errors for congruence when visual examination occurred first. This pattern of findings suggests that there is a dominant visual process involved in visual-haptic memory representation.

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Acknowledgments

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Visuo-Haptic Memory Representation and the Influence of Verbal Processing

Imagine there is a power outage. You are stumbling around your house, trying to find your way to a flashlight. Since it is pitch black, you cannot rely on your sight. Instead, you feel your way through your house. With your sense of touch, you can quickly figure out what things are—that is a doorknob, that is the railing for the stairway, that is a cabinet, and so on. Once you find your way to a flashlight, you have a light source, which means you no longer must rely on your sense of touch, because now you can see. With your sight back, you know what is what—that is the door to the bathroom, that is the stairs to go to the second floor, and so on. These are just some examples of our visual (sight) and haptic (touch) memory representation works. However, have you thought about what might happen if you saw an object first, and then later determine if another object is the same or not just by touch (or vice versa)? Research has shown that this is possible, however, how does it happen? One explanation is that these memory representations share a verbal code. Therefore, the current study aimed to look at how verbal distractions affected participants' ability to create memory representations of objects.

Shared Representation

Past findings suggest that both the visual and haptic memory systems rely on similar mental representations. Norman et al. (2004) investigated how these systems worked by comparing the performance of participants whose learning and testing conditions matched to the performance of participants whose learning and testing conditions didn't match. From the matching and non-matching conditions, the authors observed that for 3D objects, participants found it harder to notice local changes (slight/minor changes in object) and were sensitive to global changes (overall/large changes in object). The results support the notion that these systems have a similar representation—Norman et al. (2004) suggest that these systems may even have overlapping representations for 3D objects.

More recent studies have also reported similar findings with cross-modal representation. Desmarais et al. (2017) investigated visual and haptic identification, and if performance depended on matching learning and testing conditions. For their study, they used novel objects and asked participants to learn to recognize these objects either by sight or by touch before asking them to recognize objects both haptically and visually. Desmarais et al. (2017) reported that when asking participants to learn to recognize novel objects haptically, they had similar performance when tested visually and when tested haptically; those who learned to recognize objects visually did best when tested visually. Desmarais and Penrose (2021) replicated these findings as well. These results suggest that there is an advantage to being tested in the same modality that you learned objects in. This observation is consistent with the encoding specificity phenomenon.

Encoding Specificity

Encoding specificity is the phenomenon first reported by Tulving and Thomson (1973) where when learning and testing conditions matched, one’s performance will be much more accurate than when learning and testing conditions do not match. They showed this phenomenon through the learning and testing of word lists. The authors gave participants pairs of words that had either strong (e.g., dark-LIGHT) or weak (e.g., ground-LIGHT) cues. When asking participants to recall words, Tulving and Thomson gave participants strong or weak cues. They reported that weak encoding (weak cues learned) and weak retrieval (weak cues given) led to better performance than weak encoding (weak cues learned) and strong retrieval (strong cues given), showing that the context influenced memory. In other words, Tulving and Thomson reported that participants could remember much more when their recall environment matched their encoding environment.

Other tasks have also shown encoding specificity, such as cross-modal object recognition. One such example is the results found by Easton et al. (1997). For their study, the authors looked at memory representations for both 2D and 3D objects. They got participants to learn either patterns or objects visually (saw the objects) or haptically (grasped/touched the objects), and later asked them to identify the patterns or objects. Overall, Easton et al. reported a modality-specific effect consistent with the encoding specificity phenomena. They reported that those who learned in one modality (visually or haptically) did much better when tested in that same modality than when tested in a different modality.

Violations of Encoding Specificity

Some studies have shown violations of encoding specificity. Easton et al. (1997) found that when doing implicit tests for both 2D patterns and 3D objects, implicit memory test performance does not show modality specificity: performance for within-modal and cross-modal implicit identification tests was comparable. Desmarais et al. (2017) also report similar findings. Specifically, they reported that those who learned to recognize haptically did not have an advantage when being tested haptically—they had similar performance when being tested haptically and tested visually, suggesting that matching learning and testing conditions do not always lead to better performance and accuracy. Desmarais and Penrose (2021) replicated these results.

Similarly, Norman et al. (2004) compared unimodal object recognition to cross-modal object recognition. Participants in their study either see the objects or haptically explore them (grasp objects) during the learning phase, and then were tested in the same or different modality. They reported that while performance in the unimodal condition was significantly better than performance in the cross-modal condition, the difference was small—more specifically, those in the vision-vision condition did better than those in the cross-modal conditions. These results add more support to the notion that matching learning and testing conditions do not always lead to better performance, as suggested by Desmarais et al. (2017).

The violations of encoding specificity tell us it is possible to learn in one modality and recognize objects in another modality without a drop in performance. These violations suggest that there is something special about the representation that is created through haptic exploration. Though there is much evidence that seems to suggest that performance and accuracy are much better when learning and testing modalities match (encoding specificity), there is also evidence that suggests that in some situations, there are violations in encoding specificity. The findings that Easton et al. (1997), Norman et al. (2004), Desmarais et al. (2017), and Desmarais and Penrose (2021) report suggest that visual and haptic representation may overlap—with Easton et al. (1997) suggesting that these systems may share a representation. However, the question is how does this occur? Past literature suggests several possible theories on the nature of shared representations.

Nature of Shared Representations

Visual Representation

There are a few theories regarding the nature of shared memory representation, one of which is Piaget and Inhelder's (1956) visual representation theory. They hypothesized that when we touch or hold an object, this will lead to a visual representation of the object that overlaps with haptic representation. In other words, whenever we touch an object, we encode it visually, suggesting that visual interference should interfere with our haptic recognition.

Lacey and Campbell (2006) directly tested the visual representation theory proposed by Piaget and Inhelder. They used two groups of objects, familiar objects that consisted of everyday household objects, and unfamiliar objects that consisted of caving and climbing equipment. The participants either saw objects (visual) or grasped objects (haptic) to learn sets of objects and then were tested in the opposite modality (e.g., learned visually, tested haptically). Lacey and Campbell used three types of distractors as well: visual interference (visual notice task), verbal interference (had to listen to an English recording), and haptic interference (had to manipulate a distractor object in their non-dominant hand). They gave the participants the distractors during the learning phase for the first experiment, and it was given to participants during the recognition phase for the second experiment. The authors had participants identify the objects they learned from a group of objects that had the target objects (objects they learned) along with distractor objects (objects that they didn't learn).

If Piaget and Inhelder’s (1956) hypothesis is correct, visual interference should have the strongest effect on the participants’ performance, whether they were tested either visually or haptically. Lacey and Campbell’s (2006) results support this hypothesis. When participants were identifying unfamiliar objects, visual interference affected their performance (took longer to identify objects and made more errors), however visual interference did not affect participants’ performance when identifying familiar objects. They note that the effect of visual interference was not significantly different from the effect of verbal interference (both interferences affected participants’ performance similarly), but they found that visual interference differed significantly from haptic interference (visual interference affected the performance of participants much more than haptic interference). Providing some support for a visual overlap between haptic and visual memory systems, however, Lacey and Campbell (2006) found that visual interference affected the performance more during visual recognition than haptic recognition (people were much slower and made more errors during visual recognition with visual distractors than in haptic recognition with visual distractors). If the visual-haptic memory systems did share a visual component, then visual interferences should affect both visual and haptic recognition equally, as Piaget and Inhelder (1956) proposed. This was not the case, suggesting that while shared representations may have a visual component to them, the shared representations do not have a dominant visual component.

Desmarais and Penrose (2021) also reported similar findings in their study. They asked half of their participants to learn to recognize objects haptically (grasped the objects), and the other half learned to recognize objects visually (saw the objects).

During learning trials, the authors asked participants to remember which objects were presented, and they also presented participants with one of three distractor conditions: verbal distractor (letters of the English alphabet), visual distractor (Yi symbols), or no distractor. Then the participants were asked to learn the names of each object. Finally, Desmarais and Penrose (2021) had participants complete both haptic identification trials and visual identification trials. Like Lacey and Campbell (2006), Desmarais and Penrose (2021) found that visual distractors did not seem to interfere with developing an object representation. One difference is that Desmarais and Penrose (2021) did not find any interference from visual distractors, whereas Lacey and Campbell (2006) found that visual interference affects visual recognition more than haptic recognition.

Dual Representation

Another theory of the nature of representation is Johnson et al.'s (1989) theory of dual-code representations. They theorized that object representations depended on the familiarity of objects and hypothesized that both objects that are familiar and unfamiliar are presented visually, familiar objects can also be represented verbally, as we can name these objects.

Lacey and Campbell (2006) proposed that if the dual-code representation theory proposed by Johnson et al. (1989) is true, then our representation systems would have a hierarchy of activation. Lacey and Campbell (2006) describe the hierarchy of activation as starting with a haptic representation of objects, which can lead to a visual representation, and for familiar objects, this will lead to verbal representations. As a result, they predicted that for familiar objects, haptic interference would only affect performance for those in the haptic learning-visual testing condition, and that verbal interference would only affect the recognition of familiar objects.

Lacey and Campbell (2006) did not find significant interference from haptic distractors on familiar objects for the haptic learning-visual testing condition, indicating that haptic interference does not affect performance when learning haptically. They also reported that when recognizing familiar objects, verbal interference did not affect participants' performance. Lacey and Campbell (2006) give us two possible explanations for this: one, our representations of familiar objects are too deep and stable to be affected by interference, and two, representations are not a hierarchy of activation, but rather an associative network, in other words, there is a cross-modal memory for familiar objects. This cross-modal memory for familiar objects suggests that there is an associative network made up of different representations (e.g., haptic, visual, verbal). So, when there is a visual interference, we still have other representation systems we can rely on.

Likewise, Newell et al. (2005) also investigated the recognition of scenes of familiar objects. For their study, the authors gave participants time to learn scenes visually or learn them haptically (exploring the scene with their hands but could not visually see it). during the encoding phase, they also had participants repeat the word "the" aloud repeatedly to look at how verbal suppression could affect within and cross-modal scene recognition. Overall, Newell et al. found that the verbal interference task did not affect scene recognition performance, contradicting Johnson et al.'s (1989) dual-code theory, as verbal interference did not affect the recognition of familiar objects. If Johnson et al.'s (1989) dual-code theory is true, then verbal interference would only affect the recognition of familiar objects and not unfamiliar objects. However, both Desmarais and Penrose (2021) and Lacey and Campbell (2006) found that verbal distractors affect the recognition of unfamiliar objects, suggesting that at least some familiar object representation relied on verbal information.

Amodal Theory

The amodal theory was proposed by Lewkowicz and Lickliter (1994). They hypothesized that the properties of objects could be represented in one of two ways. The first is that objects with modality-specific properties can only be perceived in one sensory modality (e.g., smell, colour). The second is that objects that can be represented both visually and haptically are represented this way because of amodal properties (e.g., texture, shape, size). Lacey and Campbell (2006) proposed that if the amodal theory is true then the performance for cross-modal conditions (haptic learning-visual testing and vice versa) would be equally accurate.

However, Lacey and Campbell (2006) found little support for this theory. They reported there was a main effect of modality: participants were more accurate in the visual-haptic conditions than the haptic-visual conditions. Lacey and Campbell reported this for both familiar and unfamiliar objects. Desmarais and Penrose (2021) also found that those who learned visually and were tested haptically made fewer errors than those who learned haptically and were tested visually. Similarly, Norman et al. (2004) found differences in their cross-modal conditions. When asking participants to determine if two objects were the same or not, the authors found that participants had similar accuracy for both same (two objects were the same) and different (two objects were different) trials when they learned haptically and were tested visually. However, when participants learned visually and were tested haptically, their performance was far better than for the same trials than different trials, suggesting that there is a stronger visual process in the visual-haptic memory representations.

Both the visual representation and dual-code theory focus on a visually mediated memory representation. While there is some support suggesting that there is a stronger visual process in the visual-haptic memory representations, past findings have reported that visual interference does not affect performance the most, and visual interference does not affect the two modalities equally (Lacey & Campbell, 2006). Instead, past studies have reported that verbal interference affects the performance of participants' the most, suggesting that there is a verbal code in the visual-haptic memory representation (Lacey & Campbell, 2006; Desmarais & Penrose, 2021).

Representations and Distractors

Past studies investigated how we develop representations using distractor tasks. Desmarais and Penrose (2021) investigated the effects of verbal and visual distractors on haptic and visual encoding. Recall that they randomly assigned participants to one of three distractor conditions: verbal distractor, visual distraction, and no distraction. Desmarais and Penrose report that only the verbal distractor affected performance—participants took longer to reach flawless performance and produced more errors with a verbal distractor task. Based on this, the authors suggested that both haptic and visual processes involve verbal processes—indicating a verbal code for memory representation. Lacey and Campbell (2006) also reported that verbal distractors had a much stronger effect on haptic and visual processes than visual distractors (though this was only found for unfamiliar objects). They also reported that overall, interference affected participants more for haptic learning-visual testing than visual learning-haptic testing.

Similar results were found by Postle et al. (2005). They asked participants do object (shapes) *n*-back tasks and spatial (location) *n*-back tasks. The *n*-back tasks had participants determine if each stimulus they were given (shape or location) is the same as the stimulus they saw *n* stimuli previously. The authors had three distractor tasks: verbal distractor (determining if a word is a noun or a verb), motion distractor (same/different tasks regarding the movement of shapes), and no-distractor. The authors found that the verbal distractor task (which involved a semantic code) affected the performance of participants the most (participants made more errors due to the verbal distractor than the haptic distractor). This observation was seen in both the object and the spatial *n*-back tasks.

Previous literature shows evidence of verbalization processes for visual and haptic representations (Postle et al., 2005; Lacey & Campbell, 2006; Desmarais & Penrose, 2021). This may explain the possible overlap between visual and haptic systems during encoding and retrieval.

Verbal Representation Bias

The results from Postle et al. (2005), Lacey and Campbell (2006), and Desmarais and Penrose (2021) suggest that our object representation involves a verbal code, no matter how we encode objects. Lacey and Campbell (2006) offer a possible explanation for the effect of verbal processing on representation: since people can still describe objects that they learn haptically or visually through thoughts, this could create a verbal representation that could be accessed at object identification. This may explain why verbal distractors seem to have a significant effect on performance during testing phases.

Desmarais and Penrose (2021) suggest that the task they used (naming objects) may have biased the participants towards a verbal representation. During the learning phase, the participants learned to associate verbal labels (e.g., YOOT, JORL) with each object. Desmarais and Penrose instructed participants to identify objects using these nonword labels. This may have biased the participants toward a verbal representation, which is what led to the verbal distraction task interfering the most with their performance (making more errors).

There are also inconsistencies regarding the nature of representations. These inconsistencies may be due to differences in people's cognitive styles (Blazhenkova & Kozhevnikov, 2008). Some individuals may prefer visual cognitive processes, while others may prefer verbal cognitive processes, and still, others may prefer spatial cognitive processes (Blazhenkova & Kozhevnikov, 2008). If distractor tasks matched one's cognitive style (e.g., verbal distractor given to one with a verbal cognitive style), the distractor task could impact the performance of a participant much more than a participant who receives a distractor task that does not match their cognitive style (e.g., verbal distractor given to one with a visual cognitive style).

Recent evidence for a verbal code may have been the result of the verbal aids created by the demands of a 'naming' task. I, therefore, aimed to evaluate the nature of object representations by using a task that did not rely on verbal processes. Participants were presented with novel objects (the same ones used by both Desmarais et al., 2017, and Desmarais & Penrose, 2021) in one modality (visual or haptic) and then presented with another object in another modality. Then they were asked to indicate if the two objects were the same or different. During the task, some participants did just the matching task, while others did concurrent distractor tasks (the same visual and verbal distractor tasks used by Desmarais & Penrose, 2021). Based on previous findings, I hypothesized:

a) Participants who complete the verbal distraction task will have slower reaction times and make more errors than those who do the visual distraction task or have no distraction task.
b) If interference taps into a participant's preferred cognitive style (e.g., visual distractor condition and visual cognitive style), they will have slower reaction times and make more errors than those whose interference does not tap into their preferred cognitive style.
c) Based on Lacey and Campbell's (2006) findings, distractor tasks will cause participants to have a slower reaction time and make more errors when they go from haptic to visual than when they go from visual to haptic.

Method

Participants

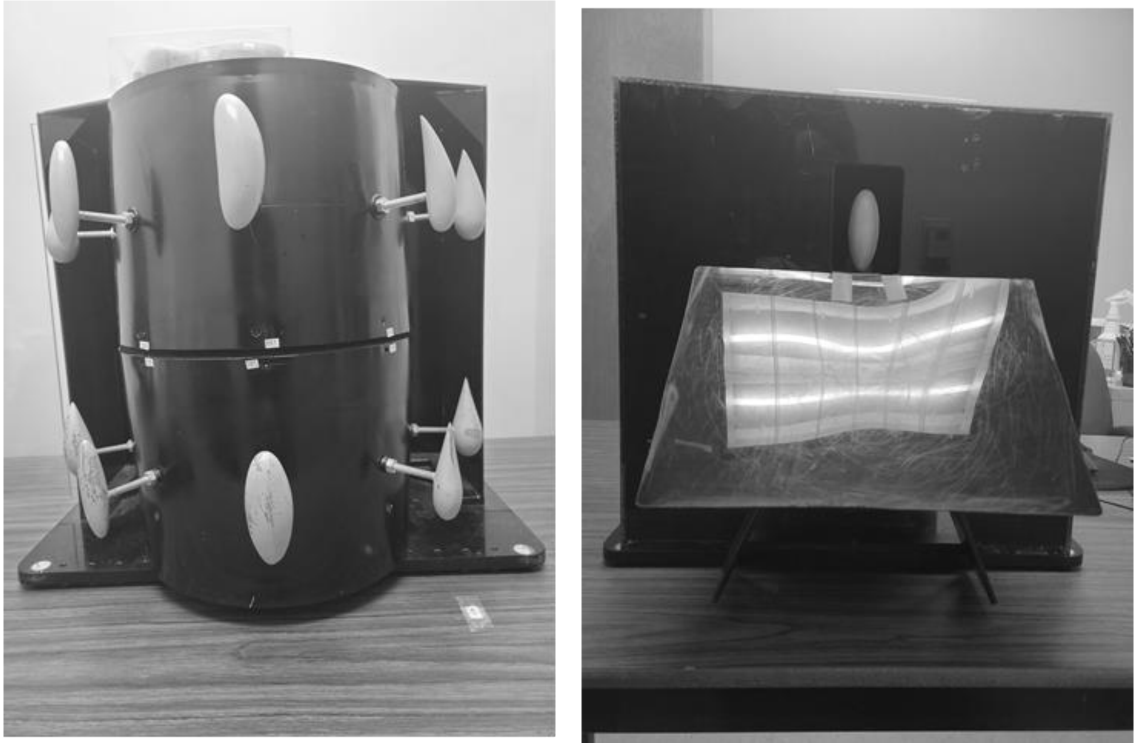
Forty-five participants were recruited from Mount Allison's introductory psychology classes and the general undergraduate student population through posters. The following exclusion criteria were used, based on the risks of complications from COVID-19 during the pandemic: those with underlying medical conditions (heart disease, hypertension, lung disease, diabetes, and cancer), those with weak immune systems from a medical condition or treatment, like chemotherapy and older adults above 65 years of age. Participants received compensation for their participation, which was either 0.5 course credits per 0.5 hours of participation or $6 per 0.5 hours of participation.

Materials

I used eight novel psychophysical scaled objects from Desmarais and Dixon (2005). Each object differed in terms of thickness, curvature, and tapering. The objects are 81 mm long and made from light gray, hard, and smooth polyvinyl chloride (PVC). The apparatus is 45 cm x 44.5 cm x 44.5 cm. Two identical sets of objects are mounted onto central spinning cylinders, stacked one on top of each other, where the top cylinder was used for visual perception and the bottom one was used for haptic perception. The cylinders can be spun separately from each other. The top cylinder has a 6.5 cm x 10 cm window, allowing participants to see one object at a time, and the bottom is set up where the participants can grasp an object without seeing it. Figure 1 shows an image of the apparatus used, along with the shapes used. The data collection of the experiment was done on Superlab 6 (Superlab, 2020).

Figure 1

Experimental Apparatus



Note. The image on the left shows the experimenter’s view (the experimenter can rotate the apparatus to show a specific object on the top cylinder or to position an object for grasping on the bottom cylinder). The image on the right shows the participants’ view (the top window allows participants to view the object, at the bottom they can grasp an object without seeing what it is).

Two distractor types were used: 26 Yi symbols (see Appendix at the end for an example) and 26 English letters. For the distraction task, each symbol and letter were presented alone on a piece of white, letter-sized paper, in 210-point size. During the testing trials, four target distractors were mixed with four lures onto a 2 x 4 grid in 110-point size.

Participants also completed an Object-Spatial Imagery and Verbal Questionnaire (OISVQ; Blazhenkova & Kozhevnikov, 2008). The OISVQ is designed to assess individual differences in object imager, spatial imagery, and verbal cognitive styles.

Procedure

Before the experimental tasks, participants completed the OISVQ questionnaire. Next, the participants completed a series of matching trials, where they were asked to determine if a haptically presented object and a visually presented object were the same or not. Participants completed one block of visual-haptic matching trials (objects are first presented visually, then haptically), and one block of haptic-visual trials (objects are first presented haptically, then visually). These two types of trials were blocked to minimize participant error (e.g., opening their eyes when they're supposed to reach for an object), and the order of the two blocks was counterbalanced across participants.

Visual-Haptic Matching Trials

Participants sat down at arm's length in front of the apparatus, with their non-dominant hand on a keyboard, and they were asked to close their eyes while the experimenter rotates the two objects into place. They were asked to open their eyes with the cue "open." After two seconds to look at the object, participants were told to close their eyes with the cue “close.” Then, participants were told to reach the object at the bottom of the apparatus with their dominant hand with the cue “reach.” Participants pressed the key labeled ‘SAME’ if the two objects were the same or pressed the key labeled ‘DIFFERENT’ if the objects are different. The participants removed their hand from the object once the response was made. The experimenter then placed the two objects for the next matching trials. Each object was presented once with each of the other seven objects, and seven times with itself, resulting in 50% of ‘same trials’ and 50% of ‘different trials.’ This resulted in a total of 112 trials.

Haptic-Visual Matching Trials

The procedure for these trials was identical to the visual-haptic matching trials, except that the participants grasped an object for fives seconds before removing their hand and opening their eyes. Again, each object was presented once with each of the other seven objects, and seven times with itself, resulting in 50% ‘same trials’ and 50% of ‘different trials’ for a total of 112 trials.

Distractor Tasks

Seventeen participants completed the task as described above. The rest were asked to complete a concurrent distractor task: 15 were asked to remember English letters, and 13 were asked to remember Yi symbols.

Participants who completed a distractor task were presented with a symbol or letter at the beginning of the first trial. Then symbols were shown every other trial (Trials 3, 5, 7, etc.). They were instructed to remember the symbols or letters, and after four symbols or letters were presented, they were asked to identify the symbols or letters they saw from a 2 x 4 grid containing all four targets along with four distractors. Once participants identified which distractors were presented, they were presented with a new distractor every other trial.

Results

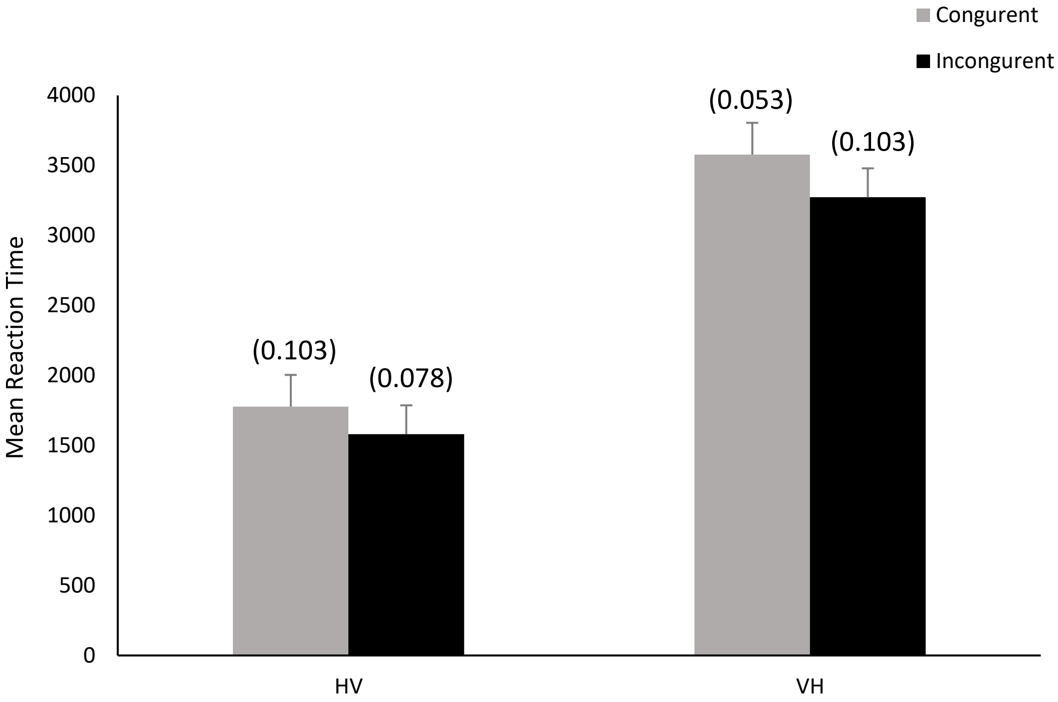
One participant dropped out partway through testing, so their data were excluded. This participant was in the visual to haptic condition and had Yi distractors. The data analyzed were from 44 participants who completed the task.

Reaction Time

Data was trimmed recursively at three standard deviations (this resulted in the removal of 428 data points or 4.342% of the data) and was entered into a 3 (distractor condition) x 2 (trial type) x 2 (congruence) mixed Bayesian ANOVA using JASP (2022), with the between-subject factor being distractor type (control, verbal, or visual) and the within-subject factors were trial type (haptic first or visual first) and congruence (same or different). The strongest model included only main effects of trial type and congruence. The BF10 for this was 1.86e31, suggesting that this data is 1.86e31 times more likely to occur when under a model with main effects of trial type and congruence, and indicating strong support for the alternative hypothesis. Overall, participants were faster for incongruent trials (*M* = 2425.986, *SD* = 1371.578) than congruent trials (*M* = 2677.536, *SD* = 1502.612), and faster when they first grasped the object before seeing the second object (*M* = 1678.525, *SD* = 848.395) and were slower when seeing the first object before grasping the second object (*M* = 3424.995, *SD* = 1381.551), as shown in Figure 2.

Figure 2

Mean Reaction Time and Mean Proportion of Errors for Congruent and Incongruent Trials for HV (Touching Object First than Seeing Another Object) and VH Trials (Seeing Object First than Touching Another Object)



Proportion of Errors

Then the data for the proportion of errors were entered into a 3 (distractor condition) x 2 (trial type) x 2 (congruence) mixed Bayesian ANOVA using JASP (JASP, 2022). The between-subject factor was distractor type (control, verbal, or visual) and the within-subject factors were trial type (haptic first or visual first) and congruence (same or different). The strongest model included a main effect of trial type, a main effect of congruence, and interaction between trial type and congruence. The BF10 for this model was 13.45 suggesting that the data is 13.45 times more likely to occur under a model with the two main effects and the interaction, providing strong evidence for the model. The interaction was analyzed using paired-sample Bayesian t-tests. When participants first grasped an object and then saw another (HV condition which is the left columns in Figure 2), participants produced similar numbers of errors when the two objects were the same (*M* = 0.103) and when the two objects were different (*M* = 0.078), BF01 = 2.46, suggesting that this data is 2.46 times more likely to occur under the null hypothesis, providing anecdotal support for the null hypothesis. In contrast, when participants first saw an object before grasping another (VH condition which is the right columns in Figure 2), they produced fewer errors when the two objects were the same (*M* = 0.053) than when the two objects were different (*M* = 0.103), BF 10 = 93.14, suggesting that this data is 93.14 times more likely to occur when under the alternative hypothesis, providing strong support for the alternative hypothesis.

Discussion

I asked participants to complete a series of matching trials, where they had to determine if a haptically presented object and a visually presented object were the same or not. Participants completed a block of visual-haptic matching trials and one block of haptic-visual matching trials. The results did not support any of my hypotheses: the distractors did not affect participants' performance. However, my results did seem to show visual dominance, as participants made more errors during incongruent trials compared to congruent trials for the VH block, however, there was no significant difference in errors for the VH block. This suggests that it was more difficult for participants to ignore objects that were presented visually first, which made responding to incongruent trials more difficult (it resulted in more errors). This observation was not seen when participants first touched an object and then saw an object (there was no significant difference in errors between congruent and incongruent trials for the HV block). This suggests that information transfers well from vision to haptics, as the visually presented object was creating interference when the participants were touching the second object.

Similar results were reported by Norman et al. (2004) who compared the performance when in matching conditions to the performance when in non-matching conditions. They noticed participants were more accurate (fewer errors) for congruent trials during the VH condition, whereas for the HV condition, participants made similar errors for both congruent and incongruent trials. Desmarais et al. (2017) also report that visual information for incongruent trials interfered with haptic identification. Lacey and Campbell (2006) observed that there were disruptions in participants' ability to recognize objects when they learned visually and were tested haptically. This suggests that when Lacey and Campbell's participants were haptically exploring the objects, they created a visual representation of the objects. These findings suggest that there is a dominant visual process involved in the visual-haptic memory representation, as participants found it difficult to ignore objects that were presented visually, however they could ignore objects presented haptically with relative ease.

Visual vs. Haptic Processing

The recording of participants' reaction time started at the cue for the second modality. This was to ensure that the HV and VH blocks could be comparable. Still, the participants were quicker to respond to the HV block than to the VH block, suggesting that there is a stronger reliance on visual processes. This finding is consistent with Desmarais et al. (2017), who reported that participants were slower for haptic identification than visual identification.

Based on previous literature, Lacey and Campbell (2006) suggest that visual dominance seen is because vision is more efficient than touch. The objects I used differ in terms of shape (curvature, thickness, and tapering), and the texture of the objects are the same (smooth polyvinyl chloride). Since the objects only differed in terms of shape, it might have been more efficient for visual processes at determining differences than the haptic processes (visualizing something fatter/thinner, sharper/rounder edges, etc., may be easier than haptically processing it). This is because vision can encode the entire visual field, whereas the haptic perception can only encode/process information more serially.

Another possible explanation that Desmarais et al. (2017) suggest is that this difference may be due to how long it takes participants to reach and grasp objects. For visually presented objects, the participants only need to look at the object, whereas for haptically presented objects the participants had to reach with their dominant hand and explore the object. The study did find that participants were faster for the HV block than the VH block, suggesting that people respond to visual stimulus faster than a haptic stimulus, which may be due to the time it takes participants to reach and grasp the objects.

Incongruent vs. Congruent

Overall, participants had a quicker reaction time for incongruent trials, they were quicker to differences than similarities, and as a result, they rejected differences quicker. Desmarais et al. (2017) report that during their third experiment, participants were slower for congruent trials. One explanation for why they were quicker for incongruent than congruent trials is due to the objects used in the current study. The objects used could differ from one another in three aspects (curvature, thickness, and tapering). Participants took longer to conclude that two objects are similar because they need to go through all three possibilities, whereas if the two objects are different, they only need to notice one difference. Since participants only need to find one difference, they would be faster at responding to incongruent trials, whereas for congruent trials, participants would have to go through all three possibilities.

Ineffectiveness of Distractors

Overall, the results did not support my hypotheses of distractors interfering with participants’ performance. This is most likely due to not having enough participants to detect an impact from the distractor types. Desmarais and Penrose (2021), who used the same distractor tasks as the ones in the current study, recruited over 100 participants for their study, and they were able to detect the impact of the distractor tasks. I was only able to recruit 45 participants, which may have prevented me from detecting interference effects. Future studies should aim to recruit around the same amount as Desmarais and Penrose so that an impact from the distractor tasks can be detected.

The current study aimed to look at the memory representations shared by visual and haptic systems but was limited by the pandemic. As a result, the current study does not support the notion of a verbal component for the visual-haptic systems. However, the results of the study support the notion that there is a dominant visual process in the visual-haptic memory representation, as people find it harder to ignore visually presented objects than haptically presented objects.

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Appendix

Yi Symbols

Figure 1. Examples of Yi symbols that will be presented at the first trial and then every other trial (Trial 3, 5, 7, etc.).

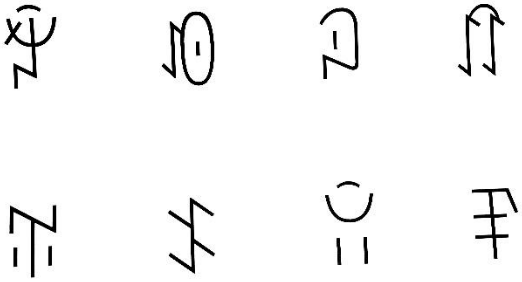

Figure 2. Example of Yi symbols that will be presented after four Yi symbols have been presented to participants (four targets and four distractors).